Metal-rich Globular Clusters: An Unaccounted Factor Responsible for Their Formation?

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Abstract. Presently unaccounted but quite probable "chemical factor" may be responsible for the formation of old metal-rich globular clusters (MRGCs) in spheroids, as well as of their conterparts, young (intermediate–age) massive star clusters (MSCs) in irregulars. Their formation presumably occurs $\sim$ at the same stage of the host galaxies' chemical evolution and is related to the essentially increased SF activity in the hosts around the same metallicity, $\sim Z\odot/3$ ([Fe/H]~ -0.5). It is achieved very soon in massive spheroids, later in lower-mass spheroids, and (much) more later in irregulars.

1 MSCs as Young Counterparts of Old MRGCs

Are merger of gas–rich spirals and multiphase collapse the only contributors to the formation of old MRGC populations? I argue that MSCs (compact populous and super–star clusters with M$\geq 10^4 M_{\odot}$) in the LMC and other irregulars are counterparts of the old MRGCs and that another reason (quantitative and qualitative changes of the dust?) leads to (favors) their formation.

Peak metallicities of MRGCs in early–type galaxies with stellar masses differing by nearly 2.5 order of magnitude are estimated by [1] to fall between $-0.7 \leq$[Fe/H]≤ -0.2. The MRGC populations are assumed to be coeval, and their color trend is fully attributed to their metallicity trend. However, this is not supported by data on timing of spheroids' formation: the more massive spheroid, the shorter timescale of its formation ([2], [3], [4]). Real scatter of the MRGC peak metallicities around mean, [Fe/H]~ -0.5, may be at least twice as lower, by accepting conservative estimate of possible systematic age difference of $\sim$5 Gyr between MRGCs in spheroids of the range of mass.

According to [5], a mean metallicity of the populous star clusters formed in the LMC 1–3 Gyr ago is close to [Fe/H]= -0.5, irrespective of their age and location in the galaxy. However, metallicity of the field stars near these clusters exhibits obvious dependence on age (see Fig. 1, where squares and asterisks are data from [6] and [7], respectively). Moreover, the MDF for the disk stars of the LMC is virtually identical with that for the old red giant stars in the halo of NGC 5128 and M31 ([8]), reaching its maximum somewhere near [Fe/H]~ -0.5. Published data on generic (mean) metallicities of populations of MSCs and/or on their hosts in irregulars with increased (bursting) SF activity (NGC1140, NGC1156, NGC1313, NGC1569, NGC1705, NGC4214, NGC4449, NGC5253, NGC6745, and IC 10) show that the metallicities fall, as those of MRGCs do, around $\sim Z_\odot/3$, between $0.004 \leq Z \leq 0.008$ ($-0.7 \leq$[Fe/H]≤ -0.3). For details and references, see [9].

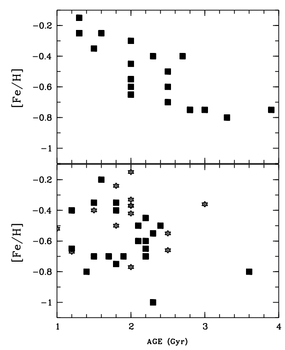

Fig. 1. Upper panel: the age–metallicity relation for the LMC intermediate–age field stars; lower panel: the same for the LMC intermediate–age populous star clusters.

2 Implications

Both the most probable formation of GCs (MSCs) and internally regulated SF activity increasing in the hosts near $\sim Z_\odot/3$ may shed more light on: the same metallicity value of the intracluster gas in galaxy clusters; starburst phenomenon in isolated galaxies; formation of MSCs in the disks of isolated spirals, etc. The difference between the age-metallicity relations for MSCs and stars in the LMC implies (provided it is the same in spheroids) different concentrations of MRGCs and stars to the centers of spheroids even under negligible GC disruption in the central parts and no merger of gas-rich spirals.

References

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